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Shao et al.

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(54) **MICRO-SPEAKER**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

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H04R 1/00	(2006.01)
H04R 7/00	(2006.01)
H04R 9/10	(2006.01)
H04R 1/24	(2006.01)
H04R 9/02	(2006.01)

(52) **U.S. Cl.**

CPC .. ***H04R 1/00*** (2013.01); ***H04R 1/24*** (2013.01); ***H04R 7/00*** (2013.01); ***H04R 9/025*** (2013.01); ***H04R 9/063*** (2013.01); ***H04R 9/10*** (2013.01); *H04R 2209/026* (2013.01); *H04R 2499/11* (2013.01)

(58) **Field of Classification Search**

CPC H04R 1/24; H04R 1/2803; H04R 1/403; H04R 9/025; H04R 9/063; H04R 9/10; H04R 2209/026; H04R 2499/11; H04M 1/03; H04M 1/035

USPC 381/335, 338, 345, 349, 350, 351, 182, 381/186, 189, 386, 388, 396, 401, 412; 181/144, 145, 199; 379/430, 431, 379/433.02

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,711,274	B2 *	3/2004	Asahina	H04M 1/03 381/182
6,744,895	B2 *	6/2004	Miyamoto	H04R 9/063 381/182
7,142,686	B2 *	11/2006	Furuya	H04M 1/035 381/182

* cited by examiner

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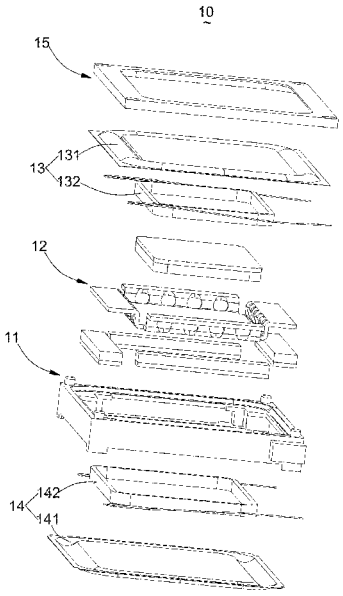
(57) **ABSTRACT**

A micro-speaker is disclosed. The micro-speaker includes a frame, a magnetic circuit unit in the frame, a first vibration unit, and a second vibration unit. The magnetic circuit unit forms a first volume cooperatively with the first vibration unit, and a second volume cooperatively with the second vibration unit. The magnetic circuit unit further includes an aperture for communicating the first volume with the second volume for enabling the first vibration unit in phase with the second vibration unit.

13 Claims, 5 Drawing Sheets



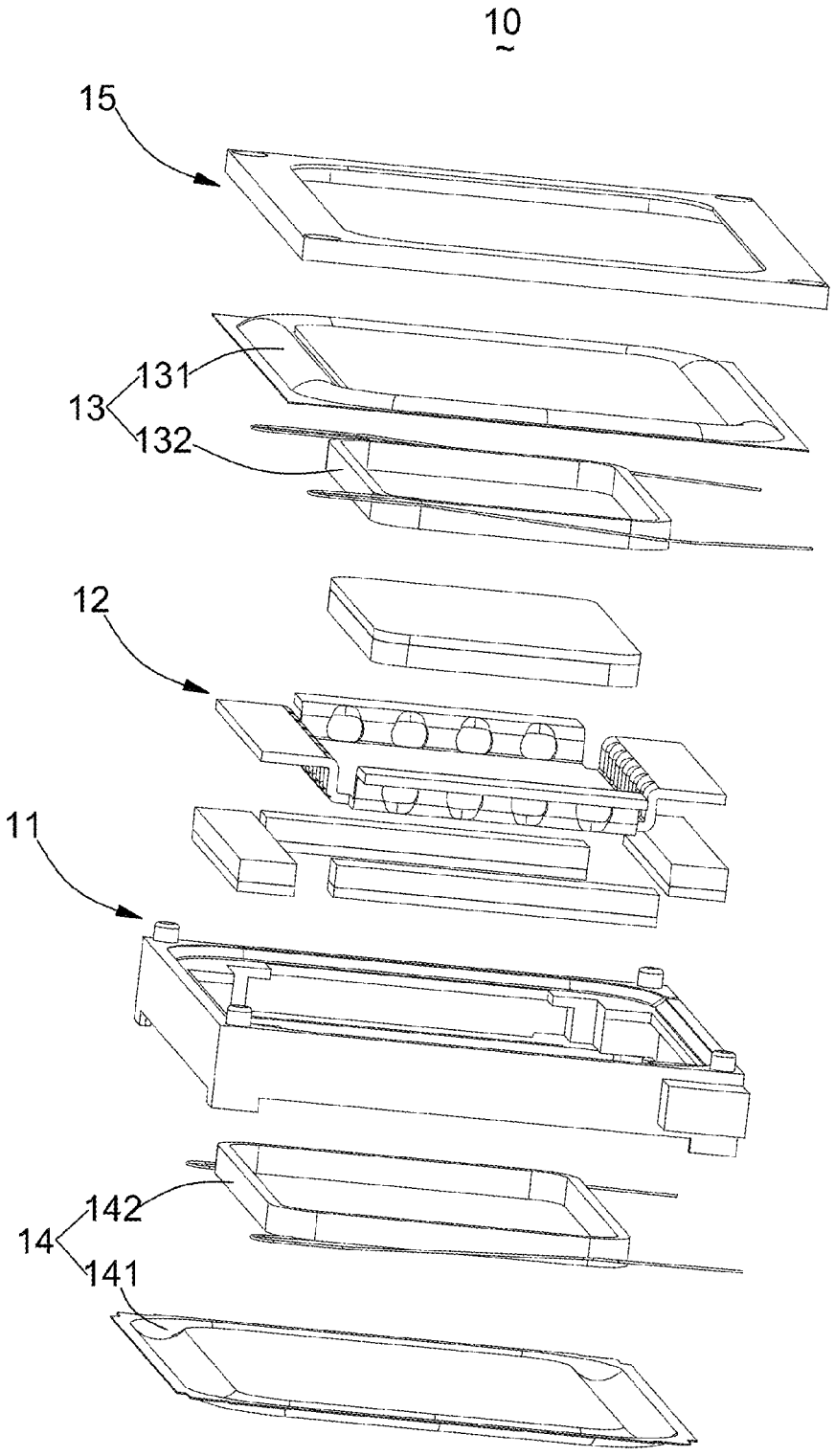


Fig. 1

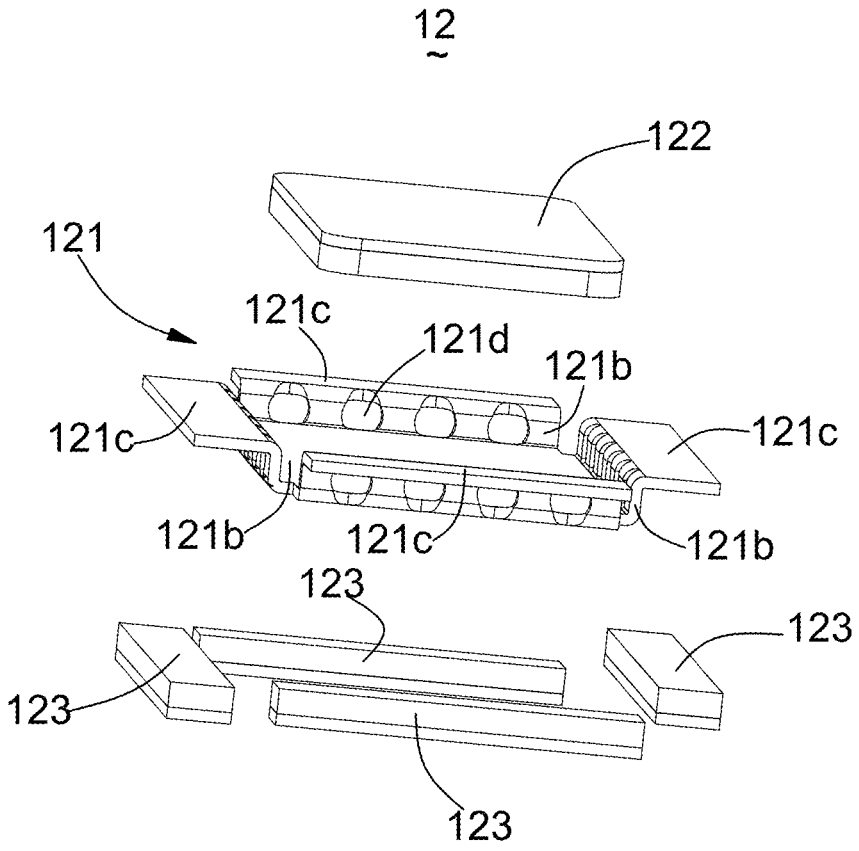

12
122
121
121c
121d
121b
121c
121c
121b
121c
121b
123
123
123
123

Fig. 2

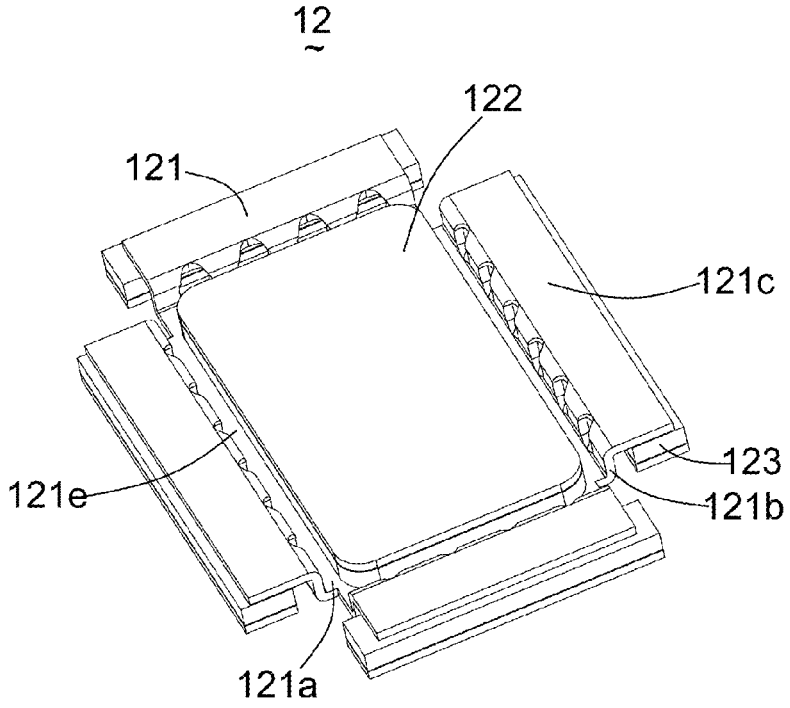

12
122
121
121c
123
121e
121b
121a

Fig. 3

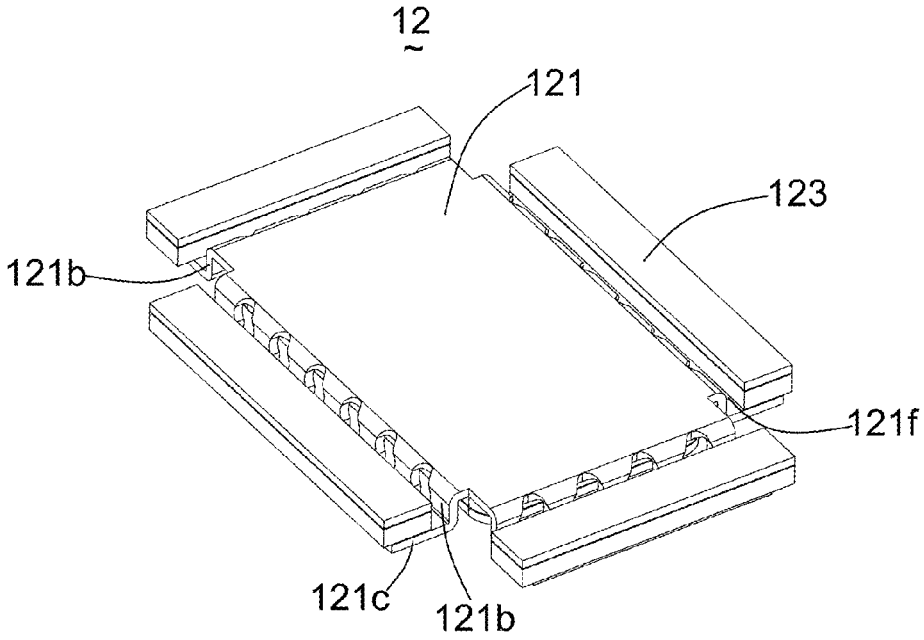

12
121
123
121b
121f
121c
121b

Fig. 4

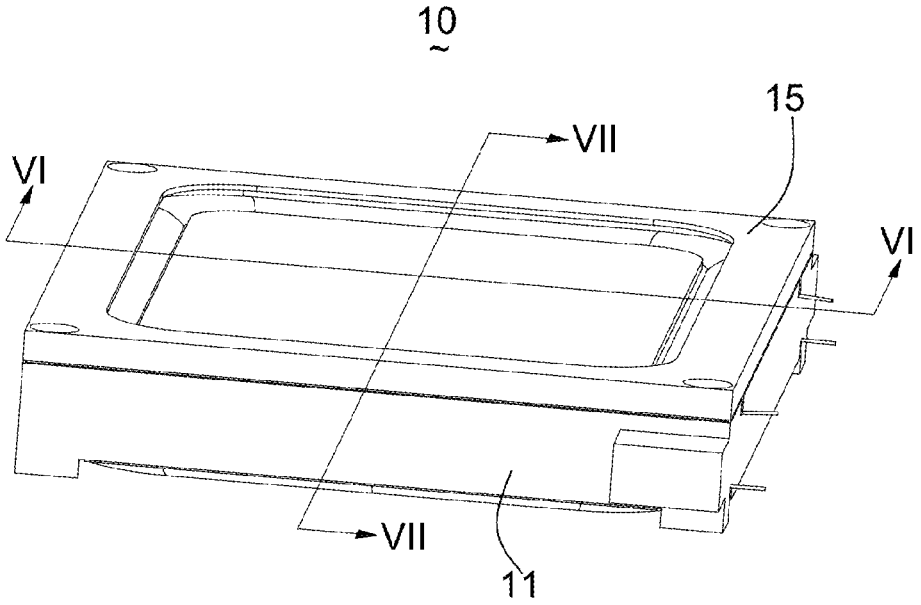

10
15
VII
VI
VI
VII
11

Fig. 5

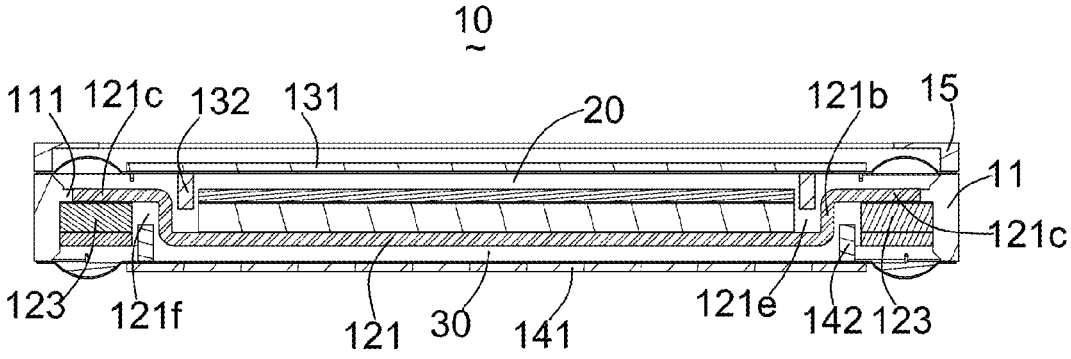

10
111
121c
132
131
20
121b
15
11
121c
123
121f
121
30
141
121e
142
123

Fig. 6

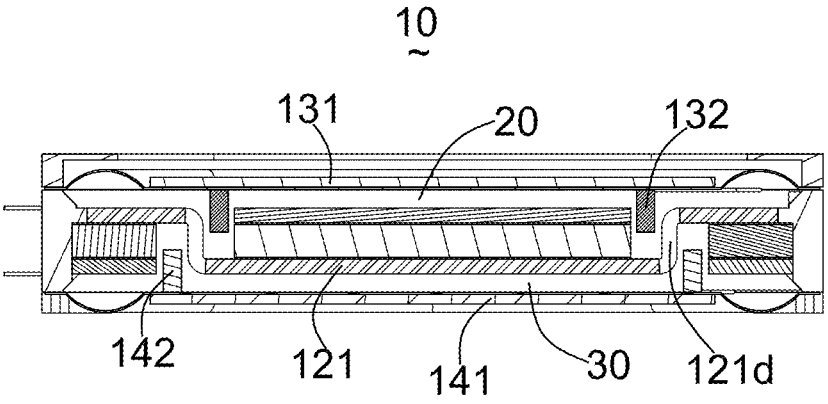


Fig. 7

MICRO-SPEAKER

FIELD OF THE INVENTION

The present invention relates to electroacoustic apparatuses, more particularly to a micro-speaker used in an electronic device for converting electrical signals to audible sounds.

DESCRIPTION OF RELATED ART

Sound which can be heard by a person's auditory sense is transmitted in the form of waves. The sound having the wave form moves air molecules and vibrates the tympanic membrane, thus allowing a person to hear the sound. In order to provide audible sounds, various kinds of micro-speakers have been developed. An micro-speaker is generally coupled to an audio equipment or an amplifier for use as a large sound producing means for considerably amplifying volume. Alternatively, the micro-speaker may be used as a small sound producing means having a small size and volume.

An electronic device, such as a cellular phone, a camcorder, a PDA, a digital camera, or a notebook computer, provides a space for accommodating a micro-speaker therein. Nowadays, a micro-speaker with high quality audio performance and miniature size is desired.

A typical micro-speaker related to the present disclosure includes a vibration unit having a diaphragm, a magnetic circuit unit having a magnet, and a housing for receiving the vibration unit and the magnetic circuit unit therein. For improving the low frequency sound performance, this kind of micro-speaker generally provides a diaphragm or a magnet having relatively greater weight. Or, the micro-speaker includes two speaker units having the same configurations. Diaphragm having greater weight, however, will result in unbalanced vibration which will badly affect the sound quality. Larger magnet or two speaker units will increase the volume of the micro-speaker.

Accordingly, an improved micro-speaker which can overcome the disadvantages described above is desired.

BRIEF DESCRIPTION OF THE DRAWINGS

Many aspects of the embodiment can be better understood with reference to the following drawings. The components in the drawings are not necessarily drawn to scale, the emphasis instead being placed upon clearly illustrating the principles of the present disclosure. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

FIG. **1** is an isometric and exploded view of a micro-speaker in accordance with an exemplary embodiment of the present disclosure.

FIG. **2** is an exploded view of a magnetic circuit unit of the micro-speaker in FIG. **1**.

FIG. **3** is an assembled view of the magnetic circuit unit in FIG. **2**, from a first aspect.

FIG. **4** is an assembled view of the magnetic circuit unit in FIG. **2**, from a second aspect opposed to the first aspect.

FIG. **5** is an isometric and assembled view of the micro-speaker in FIG. **1**.

FIG. **6** is a cross-sectional view of the micro-speaker taken along line VI-VI in FIG. **5**.

FIG. **7** is a cross-sectional view of the micro-speaker taken along line VII-VII in FIG. **5**.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENT

The present invention will hereinafter be described in detail with reference to an exemplary embodiment.

Referring to FIG. **1** which is an isometric and exploded view of a micro-speaker **1***o* in accordance with an exemplary embodiment of the present disclosure, the micro-speaker **10** is used in an electrical device such as a notebook, a mobile phone, a portable consumer device for converting electrical signals to audible sounds. The micro-speaker **10** includes a frame **11**, a magnetic circuit unit **12** positioned by the frame **11**, a first vibration unit **13** supported by the frame **11**, a second vibration unit **14** supported by the frame **11**, and a cover **15** engaging with the frame **11** for forming a housing. The first and second vibration units **13**, **14** interacts with the magnetic circuit unit **12** for producing sounds by means of vibrations. The first vibration unit **13** includes a first diaphragm **131** and a first voice coil **132** directly or indirectly connecting with the first diaphragm **131**. Similarly, the second vibration unit **14** includes a second diaphragm **141** and a second voice coil **142** directly or indirectly connecting with the second diaphragm **141**. When electrified, the first and second voice coils **132**, **142** drive the first and second diaphragms **131**, **141** to vibrate for generating audible sounds due to Lorenz Force produced by the interaction between the voice coils and the magnetic circuit unit **12**.

Referring to FIG. **2**, an exploded view of the magnetic circuit unit **12**, the magnetic circuit unit **12** includes a yoke **121** made of magnetic conduct material, a first magnet assembly **122** coupled with the yoke **121**, and a second magnet assembly **123** couple with the yoke **121**. The first magnet assembly **122** comprises a permanent magnet and a pole plate attached to the permanent magnet, or comprises a permanent magnet without a pole plate attached thereto. Similarly, the second magnet assembly **123** comprises a permanent magnet and a pole plate attached to the permanent magnet, or comprises a permanent magnet without a pole plate attached thereto. In this embodiment, the second magnet assembly **123** comprises four separated parts. In fact, alternatively, the second magnet assembly **123** may be a single ring. The yoke **121** comprises a bottom **121***a*, a plurality of sidewalls **121***b* extending upwardly from peripheries of the bottom **121***a*, and a plurality of flanges **121***c* extending perpendicularly from the sidewalls **121***b* along a direction away from a center of the bottom **121***a*. Thus, the flanges **121***c* are parallel to but not overlap with the bottom **121***a*. Further, the sidewall **121***b* defines a plurality of apertures **121***d* therethrough. FIG. **2** shows that each of the sidewalls **121***b* defines a plurality of apertures **121***d*. In fact, only selected sidewalls **121***b* include the apertures **121***d*, and other sidewalls **121***b* do not include the apertures **121***d*. Another word, at least one of the sidewalls **121***b* includes at least one aperture **121***d*.

Referring to FIG. **3**, an assembled view of the magnetic circuit unit **12**, the first magnet assembly **122** locates on the bottom **121***a* of the yoke **121**, with an outer surface thereof keeping a distance from the sidewalls **121***b* of the yoke, for forming a first magnetic gap **121***e* between the outer surface of the first magnet assembly **122** and the sidewalls **121***b*.

Referring to FIG. **4** that is an assembled view of the magnetic circuit unit **12** from another aspect opposite to FIG. **3**, the second magnet assembly **123** locates on the flanges **121***c* with an inner surface thereof keeping a distance from the sidewall **121***b* for forming a second magnetic gap **121***f*. By virtue of the configuration described above, the first and second magnet assemblies **122**, **123** define two magnetic gaps

121*e*, 121*f* formed at two opposite sides of the yoke **121**, and the sidewall **121***b* is a common component for forming the two magnetic gaps.

Referring to FIGS. **5-7**, when assembled, the cover **15** engages with the frame **11** for providing the housing to accommodate the magnetic circuit, the vibration units therein. The frame **11** includes an inner rib **111** extending toward a center thereof for abutting against the flanges **121***c* of the yoke to position the yoke in the frame **11**. An edge of the first diaphragm **131** attaches to an upper surface of the frame **11**, and an edge of the second diaphragm **141** attaches to a lower surface of the frame **11**. The first voice coil **132** suspends in the first magnetic gap **121***e* with one end thereof connected to the first diaphragm **131**. The second voice coil **142** suspends in the second magnetic gap **121***f* with one end thereof connected to the second diaphragm **141**. A first volume **20** is formed between the first diaphragm **131** and the yoke **121** and the first volume **20** is communicated with the first magnetic gap **121***e*. A second volume **30** is accordingly formed between the yoke **121** and the second diaphragm **141**, and the second volume **30** is communicated with the second magnetic gap **121***f*. Optionally, a part of the second magnet assembly **123** locates on the flange **121***c* of the yoke **121**, and another part of the second magnet assembly **123** locates on the inner rib **111** of the frame **11**, thereby increasing the distance between the inner surface of the second magnet assembly **123** and the sidewall **121***b*. In addition, by virtue of the second magnet assembly **123** which is contemporary attached to the flange **121***c* and the inner rib **111**, the frame **11** and the magnetic circuit unit can be coupled to each other firmly.

Referring to FIG. **7**, the first volume **20** is separated from the second volume **30** by the yoke **121**, but is communicated with each other via the aperture **121***d* defined in the sidewall of the yoke **121**. When the first diaphragm **131** moves downwardly due to the Lorenz Force produced by the first voice coil **132**, the air in the first volume **20** will be pressed and leak into the second volume **30** via the aperture **121***d* thereby pushing the second diaphragm **141** to move downwardly. Thus, the first and second diaphragms move in a same direction. Similarly, when the first diaphragm **131** move upwardly, the first volume **20** will be enlarged and the air in the second volume **30** will flow into the first volume **20** thereby forcing the second diaphragm **141** to move upwardly. The same situation will accordingly occur when the second diaphragm move initiatively. Synchronous movements of the first and second diaphragms along the same direction will effectively enhance the low frequency sound quality. Alternatively, the first and second voice coils may be electrified by one electrical signal contemporarily.

It is to be understood, however, that even though numerous characteristics and advantages of the present embodiment have been set forth in the foregoing description, together with details of the structures and functions of the embodiment, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A micro-speaker, comprising:

a frame providing a receiving space;

a magnetic circuit unit accommodated in the receiving space, the magnetic circuit unit including a first magnetic gap and a second magnetic gap arranged at two opposite sides of the magnetic circuit unit, the magnetic circuit unit further including an aperture;

a first vibration unit including a first diaphragm and a first voice coil with an end suspending in the first magnetic gap for driving the first diaphragm;

a second vibration unit including a second diaphragm and a second voice coil with an end suspending in the second magnetic gap for driving the second diaphragm;

a first volume formed between the first diaphragm and the magnetic circuit unit;

a second volume formed between the second diaphragm and the magnetic circuit unit, the second volume being separated by the magnetic circuit unit from the first volume and communicated with the first volume via the aperture;

the magnetic circuit unit including a yoke, a first magnet assembly positioned on a first surface of the yoke, and a second magnet assembly positioned on a second surface of the yoke opposed to the first surface;

the yoke including a bottom, a plurality of sidewalls extending vertically from the bottom, and a plurality of flanges extending vertically from the sidewalls, the flanges being parallel to the bottom.

2. The micro-speaker as described in claim **1**, wherein the first magnet assembly locates on the bottom of the yoke with an outer surface thereof keeping a distance from the sidewall of the yoke for forming the first magnetic gap, the second magnet assembly locates on the flange with an inner surface thereof keeping a distance from the sidewall for forming the second magnetic gap.

3. The micro-speaker as described in claim **2**, wherein the aperture is defined in the sidewall.

4. The micro-speaker as described in claim **1**, wherein the frame further includes an inner rib extending toward a center thereof for engaging with the magnetic circuit unit.

5. The micro-speaker as described in claim **4**, wherein a part of the second magnet assembly locates on the inner rib of the frame.

6. The micro-speaker as described in claim **1** further including a cover engaging with the frame for forming a housing.

7. A micro-speaker, comprising:

a housing forming a receiving space;

a magnetic circuit unit accommodated in the receiving space, the magnetic circuit unit including a yoke having an aperture, a first magnet assembly located on one side of the yoke, a second magnet assembly located on another side of the yoke, a first magnetic gap formed by the first magnet assembly and the yoke, and a second magnetic gap formed by the second magnet assembly and the yoke;

a first diaphragm facing the first magnet assembly for forming a first volume therebetween;

a voice coil suspended in the first magnetic gap for driving the first diaphragm;

a second diaphragm facing the second magnet assembly for forming a second volume therebetween;

a second voice coil suspended in the second magnetic gap for driving the second diaphragm;

the first volume being communicated with the second volume for enabling the first diaphragm in phase with the second diaphragm;

the yoke including a bottom, a plurality of sidewalls extending vertically from the bottom, and a plurality of flanges extending vertically from the sidewalls, the flanges being parallel to the bottom.

8. The micro-speaker as described in claim **7**, wherein the first magnet assembly locates on the bottom of the yoke with an outer surface thereof keeping a distance from the sidewall

of the yoke for forming the first magnetic gap, the second magnet assembly locates on the flange with an inner surface thereof keeping a distance from the sidewall for forming the second magnetic gap.

9. The micro-speaker as described in claim **7**, wherein the aperture is defined in the sidewall.

10. The micro-speaker as described in claim **7**, wherein the frame further includes an inner rib extending toward a center thereof for engaging with the magnetic circuit unit.

11. The micro-speaker as described in claim **10**, wherein a part of the second magnet assembly locates on the inner rib of the frame.

12. The micro-speaker as described in claim **7**, wherein the frame further includes an inner rib extending toward a center thereof, a part of the second magnet assembly locates on the inner rib and another part of the second magnet assembly locates on the flange.

13. The micro-speaker as described in claim **7** further including a cover engaging with the frame for forming a housing.

* * * * *